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Endarterectomy of the Internal Carotid Artery

O. G. DAVIES, JR., M.D., J. D. THORBURN, M.D., AND PARKER POWELL, M.D., *Fresno*

■ *Results of 219 operations in 171 patients for arteriosclerotic stenosis of the internal carotid artery were consistently good in patients with lateralizing, transient ischemic attacks. Although less consistent, relief of symptoms may be expected in a high proportion of patients with significant stenosis and more nonspecific symptoms. A small number of patients (10 percent) may have significant stenosis without a bruit. Asymptomatic stenosis, which has an unpredictable prognosis, may be operated upon with low mortality and morbidity. The use of local anesthesia and shunting when necessary proved to be the safest technique for the authors.*

DESPITE AN EVER GROWING NUMBER of reports on the surgical treatment of carotid artery stenosis due to arteriosclerosis, there still remains considerable difference of opinion regarding diagnosis, indications for treatment, and the technique of surgical correction. The purpose of this report is to present a method of management in these disputed areas. In the series being analyzed, there were 219 sides operated upon in 171 patients. The age distribution was from 39 to 83 years, and there was a slight preponderance of male over female patients (85 and 73 respectively). These patients were all operated upon, by one of the three authors, consecutively from 1959 through 1970.

Diagnosis and Presenting Complaints

There has been little attempt to correlate the results in surgically treated patients with the variable presenting symptoms which may be attributed to the cerebral ischemia. It was apparent in this series that certain symptoms—namely headache, syncopy, confusion, memory loss, dizzy spells, visual disturbances, tinnitus, hearing disturbance, and numbness—were nonspecific symptoms and may or may not be a result of vascular insufficiency.

When one examines the results as to relief of the presenting symptom in patients with carotid artery stenosis, it is notable that patients with classical transient ischemic attacks and lateralizing signs have consistently better results than those with less specific symptoms.

In this series of patients, there were 79 who presented with what was considered typical symptoms of transient, unilateral weakness, speech impairment and varying degrees of syncopy. In 56 patients, the symptoms were classified in the nonspecific category. Although the symptoms in these patients were compatible with cerebral ischemia, they could also have been due to other causes such as primary ear or eye disease, epilepsy or heart block. Nine patients were operated upon within two weeks of the development of an acute stroke. The degree of neurologic deficit was "fixed" at the time of operation. In 27 patients the stenosis was asymptomatic and was noted incidental to ex-

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Reprint requests to: O. G. Davies, M.D., 159 North Thesta Street, Fresno, Ca. 93701.

amination for other causes. Often, these patients had disabling vascular disease elsewhere requiring repair, and it was felt that the carotid stenosis should be corrected before other major operation was undertaken. Some of the patients were in good health and were noted to have a bruit incidental to routine physical examinations. All the asymptomatic patients underwent endarterectomy without complications and remained asymptomatic.

Although some data are available regarding the prognosis of the untreated patient with transient ischemic attacks,[1,2] it is impossible to say what the outcome would have been without surgical intervention for the asymptomatic patients. Since it is not unusual that major stroke is the first manifestation of internal carotid occlusion, perhaps some of these patients would have had neurologic deficit if total occlusion had taken place.

Physical Findings

The most valuable diagnostic sign indicating stenosis was the presence of a bruit over the carotid bulb.[3] However, there were 21 patients in the series (approximately 10 percent) studied by arteriography who, in spite of the absence of carotid bruits, proved to have narrowing of the vessel of 50 percent or greater. We believe that arteriograms should be obtained even in the absence of a bruit if the clinical history is typical but that such studies may be withheld if the symptoms are vague. Since provocative testing by compressing the vessels is inconclusive and may be dangerous,[4] we do not use it as a diagnostic maneuver. Most of these patients showed an absence of neurological deficit at the time of operation, although an occasional patient with chronic neurologic deficit has shown favorable response to carotid endarterectomy. Ophthalmodynamometry studies were done in several patients in the early part of the series but the results were too equivocal to be of any value as a screening procedure.

X-ray Examination

Rather than use a standard method for each examination, we tailored the method of arteriography to the patient's condition. In the early part of the series, open and percutaneous direct injection of contrast media into the common carotid artery was the method. Direct exposure of the vessel was used in preference to percutaneous injection since it lessened subintimal injection and at subsequent operation we found less perivascular reaction due to leakage at the needle puncture site. Arch studies were used in instances where there were bruits over the vessels at the arch, or the symptoms suggested posterior brain involvement, or blood pressure differentials were present. More recently, catheterization of individual vessels by way of the arch catheter provided the same clarity of visualization without incurring the risk of direct percutaneous injection of the carotid arteries. Direct injection of the carotid arteries may be required in situations where the arch catheter (passed by either the femoral or subclavian routes) cannot be manipulated to provide selective injection of the carotid arteries.

Timing of Operation

In four patients treated early in the series, "strokes" of severe magnitude had occurred within the first 24 hours following x-ray study. Three of these occurred in the recovery room shortly after study. The patients were returned to the operating room and endarterectomy of the vessel was done within a half hour of the onset of symptoms. In all of these patients there was progression of neurologic findings, with coma and death in two cases. This experience, together with that of other observers[5,6,7] led to the conclusion that it is unwise and dangerous to revascularize the fixed "stroke" in the acute phase. If the symptoms of the acute "stroke" clear promptly, the brain is merely blanched but not infarcted and early revascularization is imperative. We believe that if the process resolves in the first day or two, these are reversible changes in the tissue. The patient in these precarious circumstances, who is fading in and out of neurologic deficit, is taken directly to the operating room for emergency endarterectomy, but first the carotid bulb is exposed and x-ray examination with a single cassette is done to confirm the stenosis (Figure 1).

Surgical Technique

As the literature indicates, there is considerable controversy regarding methods of protecting the brain during the period of occlusion.

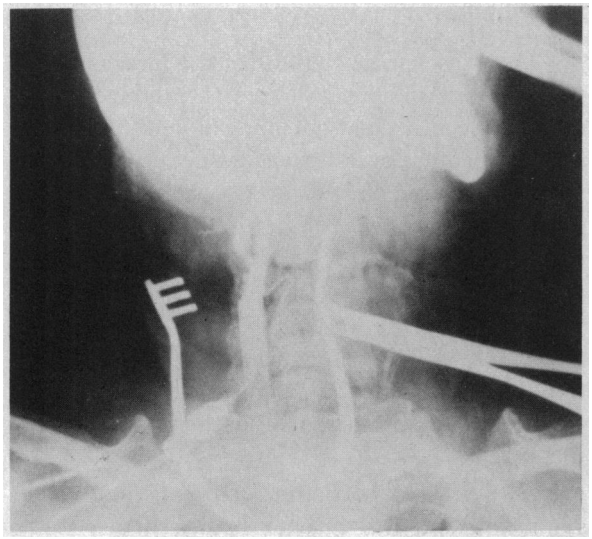

Figure 1.—Single exposure, taken in operating room, of patient in precarious condition.

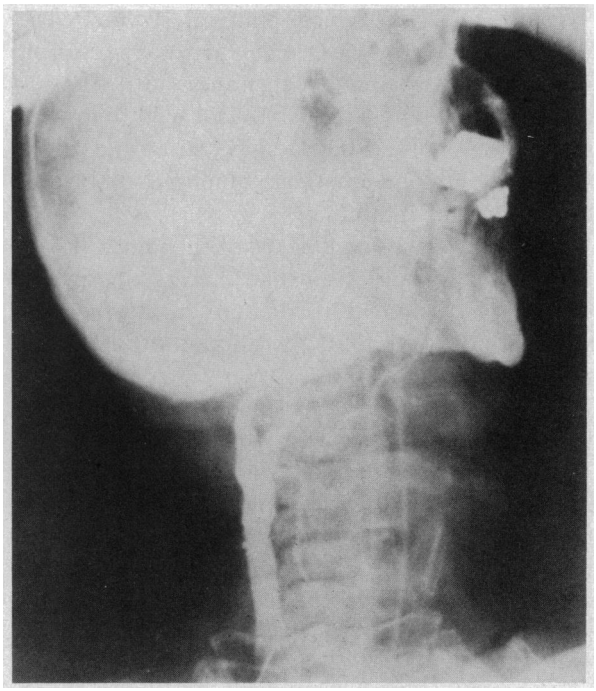

Figure 2.—After endarterectomy (same patient as in Figure 1), showing no need for "patching."

Although general anesthesia is known to lower cerebral metabolism, other adjuncts must be added to insure adequate brain protection. Hypothermia, "stump" pressure measurement, routine shunting of the vessel under general anesthesia, hypercarbia and hypocarbia have all been proposed and utilized.[8,9] It is the authors' opinion that no method of brain monitoring can be as accurate as utilizing the patient's own clinical response. With general anesthetic of any type this vital indicator of function is lost. In the first six patients in this series, general anesthesia and hypothermia were used without incident. However, the sixth patient awoke with partial hemiparesis in spite of quite adequate reduction of body temperature. Since then, all patients have been operated upon under local anesthesia. The patient is given 35 to 50 mg of heparin intra-arterially and all branches occluded for three minutes. Patients who cannot tolerate the occlusion rapidly become confused, hemiparetic, or unconscious. An internal shunt is then used and the operation completed around this bypass. Once testing has been accomplished, the supplemental use of fentanyl (Innovar®) has been very helpful for restless patients. Since shunting was necessary in only 35 patients (16 percent), use of the order of procedure here described permitted limiting treatment in 84 percent of cases to this rather simple, rapid and safe operation. Patching of the repair site was found unnecessary, for the vessel at the endarterectomy site is actually large in caliber following careful closure (Figures 1 and 2). It has been noted that the incidence of thrombosis is no different with than without patching, and that leaving an aneurysmal dilatation is as bad as a constricted area from a hemodynamic point of view.

Results

In this series of 219 sides in 171 patients, there were seven postoperative deaths in hospital. Two were due to acute myocardial infarction. Two occurred in patients operated upon in emergency for acute "fixed strokes," an operation the authors now believe is inadvisable. Three patients had acute thrombosis at the operative site and died in the early postoperative period. (It should be noted also that reoperation in the acute phase in two of these patients probably brought on additional brain damage.) The total operative mortality was 3.2 percent; but if the two patients with the fixed strokes are excluded, operative mortality was 2.3 percent, which is in keeping with that reported by others.[6,8-10] There were 25 late deaths in the series, 23 due to myocardial infarction, one to malignant disease and one incidental to other major vascular operation. Only two patients have shown late worsening of preexisting neurologic deficit. It was of interest that there were no late deaths due to "strokes."

In the cases in which bilateral studies were done there were 14 instances of total occlusion on one side associated with pronounced stenosis on the other. The patients all did well following endarterectomy on the stenotic side, and there has been only one late death among them, it due to myocardial infarction.

Contrary to the conclusions of the joint study,[10] the authors would feel that this group of patients urgently need correction of the stenotic side and that without operation the outlook is poor.

The patients surviving the operation were placed in three categories for analysis:

GROUP ONE—*Improved.* Patients with typical lateralizing "small stroke" symptoms preoperatively or with the described "atypical" symptoms which had cleared and without further attacks; or patients with late residual neurologic deficit preoperatively that cleared or improved postoperatively. Total 95.

GROUP TWO—*Worsened.* Patients who survived but had or later developed more neurologic deficit than preoperatively. Total 6. In one case these complications occurred under hypothermia.

GROUP THREE—*Unchanged.* Status remains the same as before operation; hence the value of the operation to the patient is undetermined. These include 27 patients who were asymptomatic before and remained so after operation. There were five patients who had "fixed strokes" and residual paralysis and their condition remained unchanged postoperatively. There were 28 patients whose symptoms were of the ill-defined category and continued so after operation. Total 60.

There were three patients lost to follow-up examination six months to two years postoperatively.

Conclusion

- Arteriosclerotic stenosis of the internal carotid artery of sufficient degree to produce symptoms is often a clear-cut clinical syndrome consisting of contralateral transient hemiparesis with speech impairment and an associated bruit over the carotid bulb. In this group of patients, one can expect the best results postoperatively.
- The stenotic artery may also be associated with more diffuse and nonspecific symptoms of neurologic deficit. However, since other conditions may be acting to produce these symptoms, the result in this group of patients is less predictable.
- A small proportion of patients may have significant stenosis without bruits; hence study is indicated if the symptoms are typical.
- The asymptomatic stenosis has an unpredictable prognosis and may be surgically treated with low morbidity and mortality.

ADDENDUM: In the interval since the manuscript was prepared, 42 patients have undergone a total of 53 operated sides without additional mortality or morbidity.

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